Quantifying the impact of IXP shutdowns
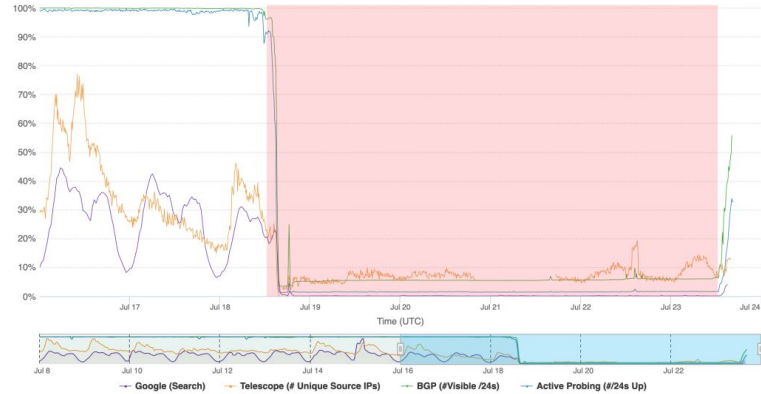
Nishant Acharya (UC Davis), Vasileios Giotsas (Cloudflare), Amreesh Phokeer (Internet Society)

# Why do we need to measure IXP shutdown impact?

Problem Statement

- *IXPs* play an increasingly important role in reducing the cost of interconnections, making them *obvious choke points*

- To understand the impact on the end user's QoS, **it is imperative to quantify and report the impact of IXP shutdowns**

- In this work we focus on IX.br Sao Paulo, Brazil

Internet Connectivity for Bangladesh
July 16, 2024 12:00am - July 24, 2024 12:00am UTC

[1] ISOC. (2024, July 23). *Shutdown - Bangladesh*. Internet Society Pulse.
https://pulse.internetsociety.org/en/shutdowns/mobile-internet-shut-down-in-bangladesh-amidst-protests/
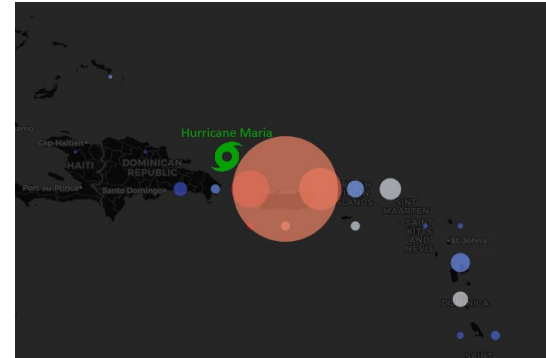
[2] "ANT Evaluation of Internet Outages Interactive

Map." *Isi.edu*, 2017, outage.ant.isi.edu/. Accessed 24

Oct. 2025.

Challenges

Challenges

1. **Incompleteness around passive data**
   a. **Existing passive data sources like AS relationships, PeeringDB and others are not complete**

2. Low visibility of IXP network fabric
   a. BGP and Traceroutes have a low visibility over IXP fabrics

3. Scalability of discovering AS level topology
   a. Brute forcing AS level discovery is non-trivial for most IXPs

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Addressing Challenges

1. **Incompleteness around passive data**

   a. Use data sources that report directly from the IXP
      i. **IXPdb[1]**

   b. Merge existing data sources to best cover for partial data
      i. Merge nearby IXP links, Traceroutes, ASRelationships[2,]

PeeringDB member information	IXPDB member information
2389	2413

[1]"The IXP Database." *Ixpdb.euro-Ix.net*, ixpdb.euro-ix.net/en/. Accessed 27 Nov. 2025.
[2]CAIDA. "Ark IPv4 prefix-probing Nov 2025" 08 Dec. 2015, https://doi.org/10.21986/CAIDA.DATA.ARK-IPV4-PREFIX-PROBING. Accessed Nov 2025.
[3]CAIDA. "AS Relationships (serial-1) Sep 2025." 01 Jan. 1998, https://doi.org/10.21986/CAIDA.DATA.AS-RELATIONSHIPS-S1. Accessed Sep 2025.

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[3]CAIDA. "AS Relationships (serial-1) Sep 2025." 01 Jan. 1998, https://doi.org/10.21986/CAIDA.DATA.AS-RELATIONSHIPS-S1. Accessed Sep 2025.

Addressing Challenges

2. Low visibility of IXP network fabric

    a.   Utilize existing non IXP links in the same city to infer the topology instead of utilizing the IXP links

Addressing Challenges

3. Scalability of discovering AS level topology

   a.   Use inferential methodologies[1]

   b.   Use closeby links away from the city

   c.   Manually Identify other IXP links in the region

[1] Salamatian, Loqman, et al. "metAScritic: Reframing AS-Level Topology Discovery as a Recommendation System." *Proceedings of the 2024 ACM on Internet Measurement Conference*. 2024.

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Addressing Challenges

Total Links: 5822569

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    c.   Manually Identify other IXP links in the region

Inferential Data Source/ Methodology	No. of discovered Links
Historical Traces	1048
Inferential Methodologies	834202
IXP Links	13110

Percentage Increase: 79499.4% increase

[1] Salamatian, Loqman, et al. "metAScritic: Reframing AS-Level Topology Discovery as a Recommendation System." *Proceedings of the 2024 ACM on Internet Measurement Conference*. 2024.
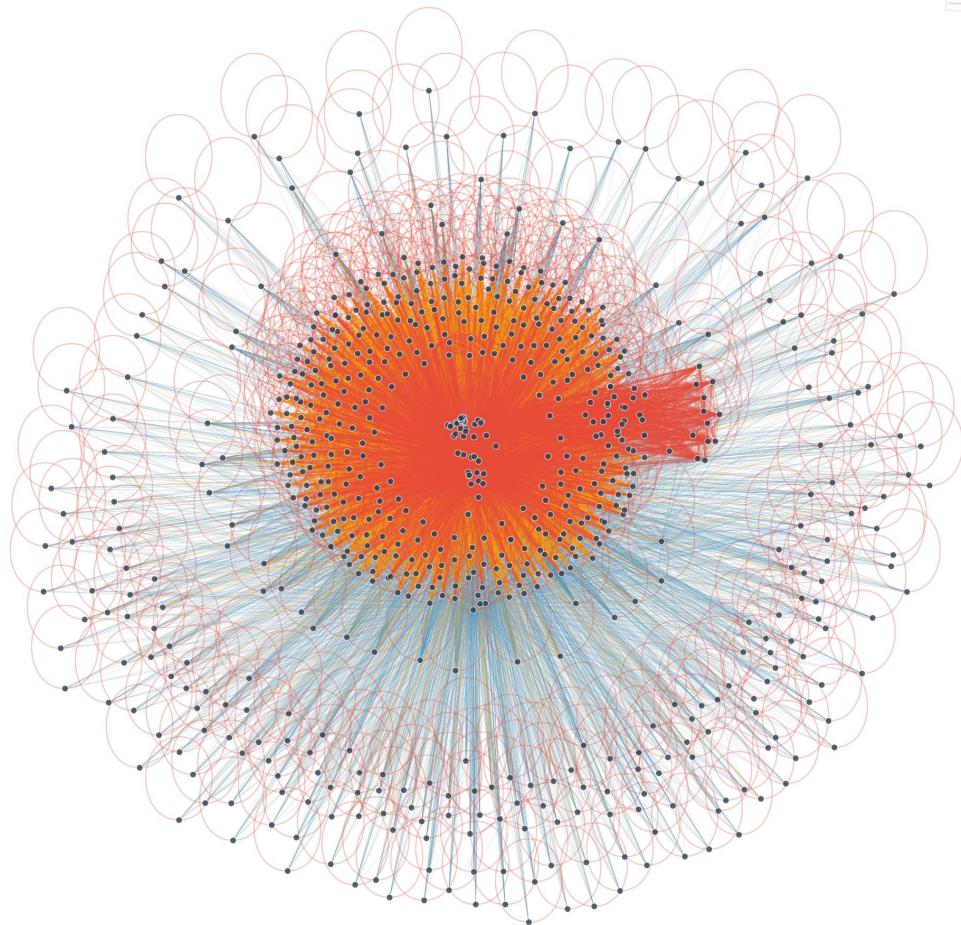
Results and Analysis

Discovered Topology

- Network graph of the 30% of links
    - **A 30% of 5822569 links**

- The confidence of the link is shown by the gradient of the edges
    - Grey → Orange : 0.25 → 1.0

Topology Takeaways

1. We were able to increase the number of labelled links and probable links by a huge margin (**846264 more links**) as compared to just looking at historical trace data

2. The number of links to measure directly is large (**over 5 million**) and hence just using active measurement to infer not observable links is not scalable
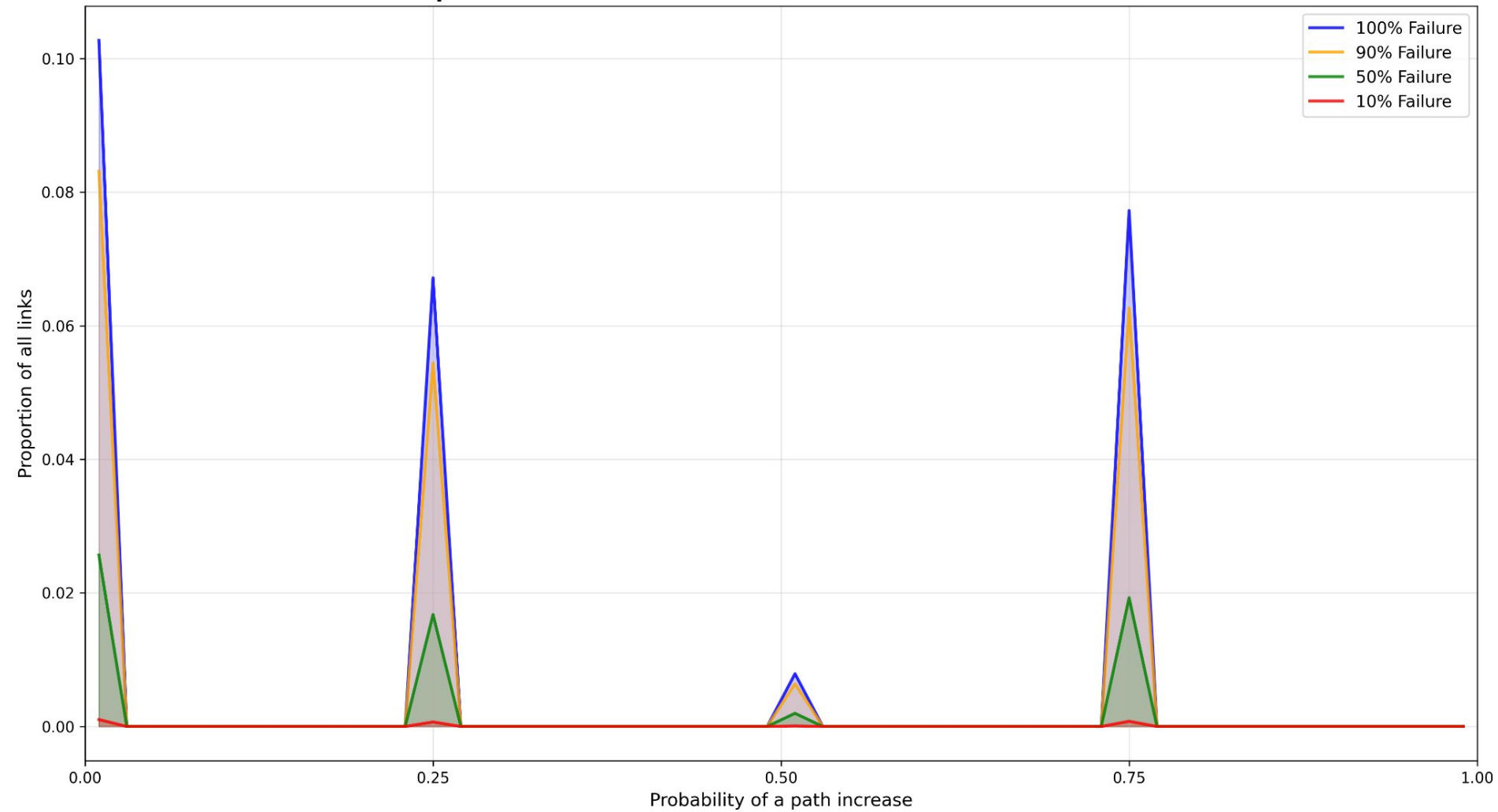
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Path increase Inference - Process

1. We analyze multiple failure scenarios (100%,90%,50%,10%)

2. For all scenarios other than 100%, we run the simulations for 1000 iterations
    Each iteration removes the respective amount of ASes and links

3. Path increase is only recorded for known non-links and probable non-links
    a.   A link is existing if we can observe it in existing data
    b.   A link is non existing if we can see a consistent non direct link between two ASes
    c.   We utilized customer cone, traffic information, number of IPv4 IPs, peering policy to check for
         probable existing links based on similarity to existing links and non links

Comparison of Path Increase Probabilities Across Failure Scenarios

Legend:
- 100% Failure
- 90% Failure
- 50% Failure
- 10% Failure

Y-axis: Proportion of all links

X-axis: Probability of a path increase

Path increase takeaway

1. Based on the previous graph, we can conclude that discovery of the AS non links is biased towards particular ASes

2. Given that a majority of the links are unknown (-1) due to non consistent routing patterns, the ~12% path increase is a lower bound on the number of path increases

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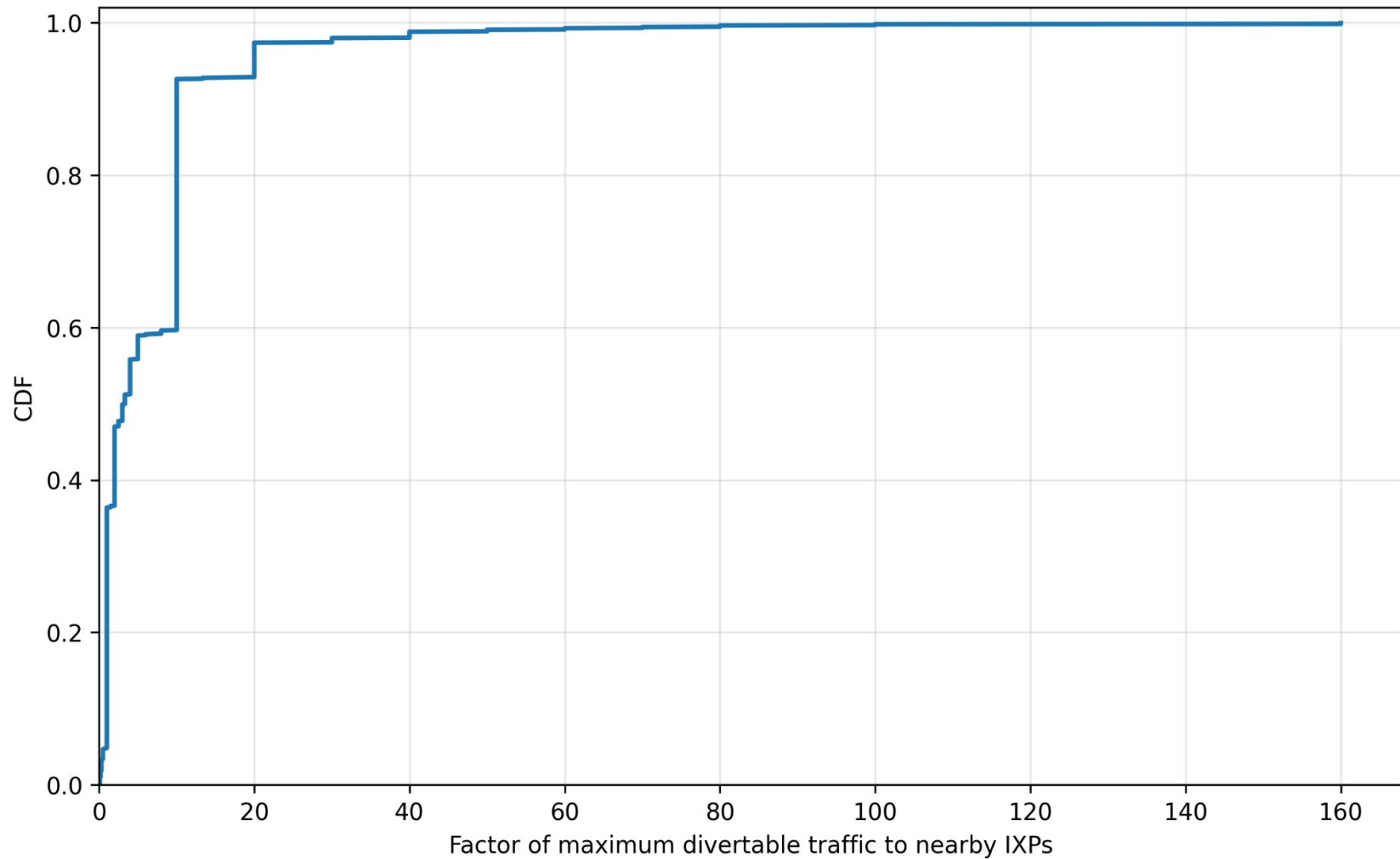
Effect on nearby IXPs

1. When a IXP fully or partially fails, it can have a cascading effect on other IXPs

2. There are 2 other IXP facilities in the Sao Paulo region DEC-IX and EdgeIX

3. We found 13110 AS pairs that overlap with the above two IXPs

4. For these, we find the AS links for which the above would be the only non IX.br link and check based on that how much traffic would be diverted using peeringDB statistics

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CDF of Traffic Diversion for Overlapping AS Pairs with nearby IXPs

Effect on nearby IXPs takeaway

1. Even on a partial shutdown the effect on the nearby IXPs would be dire, and would definitely lead to a latency increase overall. Due to the cascading effect of the failure

Limitations and Ongoing Work

1. We rely on inferential methodologies → Which need more refinement to be complete

2. We utilize data sources that are partial → Peeringdb , AS relationships and others are not complete and can benefit more refinement

3. We are currently only utilizing traceroute data for active link detection, incorporating other sources like BGP updates can further enrich the data

4. We utilize a set of features to compare similarity, and the overall list of features can be expanded upon for a more accurate similarity score

Questions?